CHAPTER 15

JOINTS FOR PLAIN CONCRETE

15-1. Design Details.

A typical layout and cross section of a roadway is presented in figure 15-1 showing the location of various joint types. Figure 13-1 presents a layout of joints at intersections of plain concrete pavements. Figure 15-2 shows the layout of joints for plain concrete parking areas. Joints for RCCP are discussed in chapter 17.

15-2. Joint Types and Usage.

Joints are provided to permit contraction and expansion of the concrete resulting from temperature and moisture changes, to relieve warping and curling stresses due to temperature and moisture differentials, to prevent unsightly irregular breaking of the pavement, and as a construction expedient, to separate sections or strips of concrete placed at different times. The three general types of joints are contraction, construction, and expansion (see figs. 15-3 to 15-6.

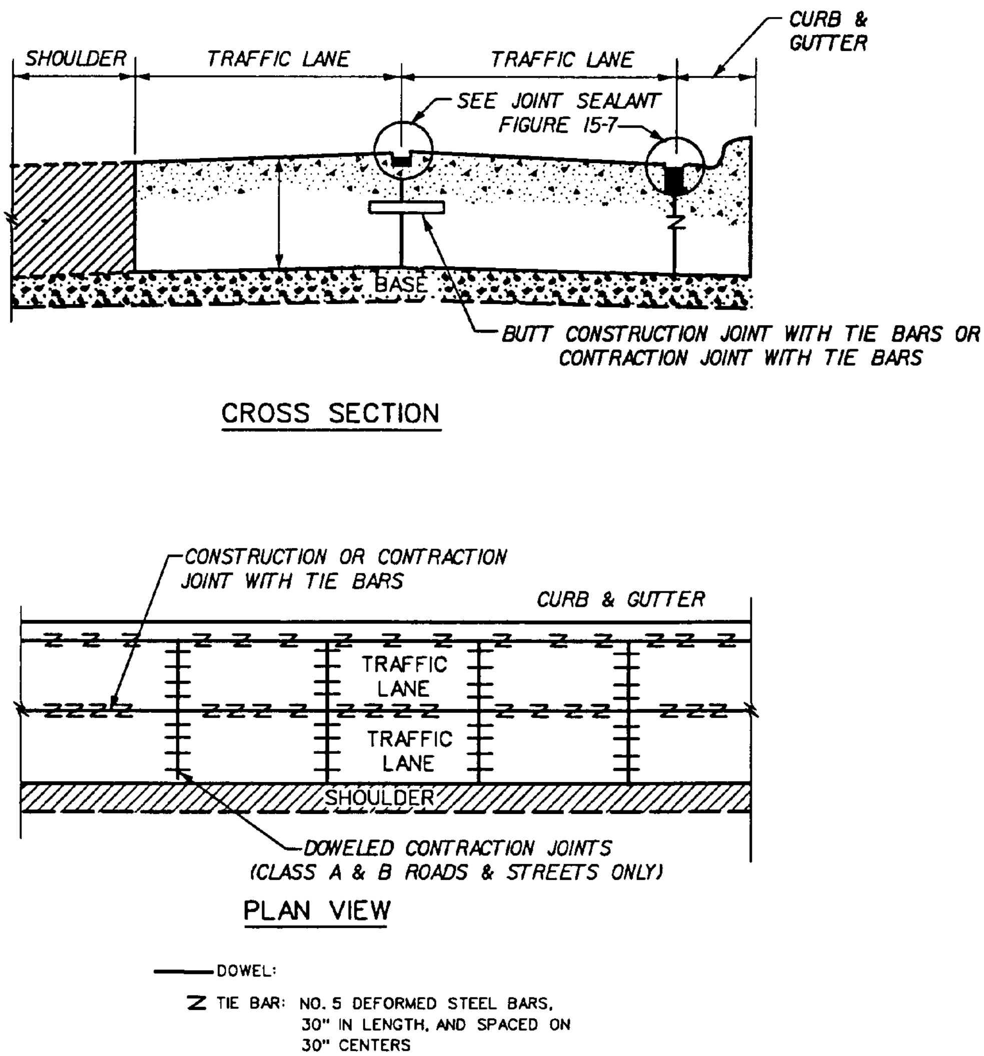


Figure 15-1. Design Details for Plain Concrete Pavements. (Sheet 1 of 2)

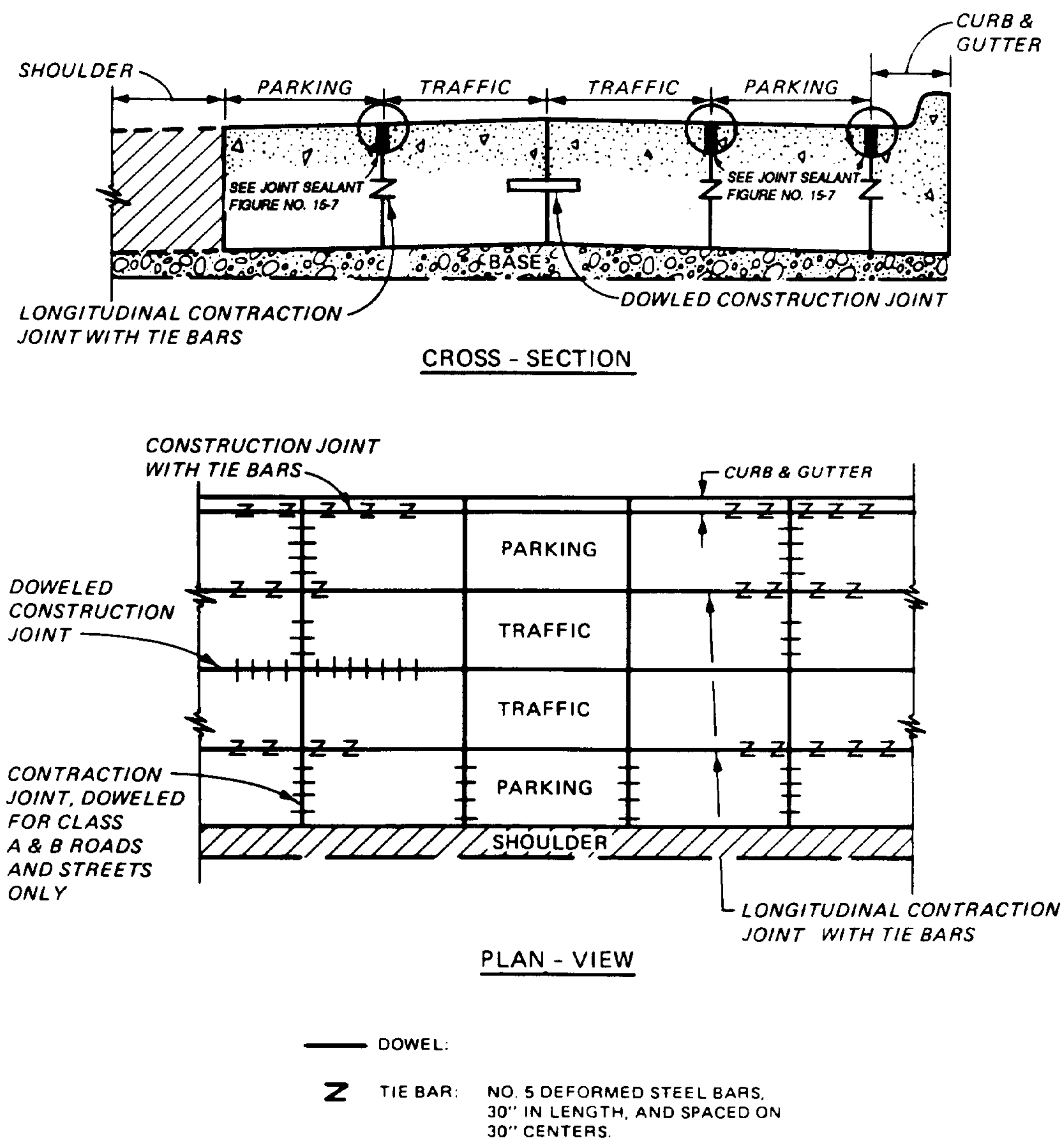


Figure 15-1. Design Details for Plain Concrete Pavements. (Sheet 2 of 2)

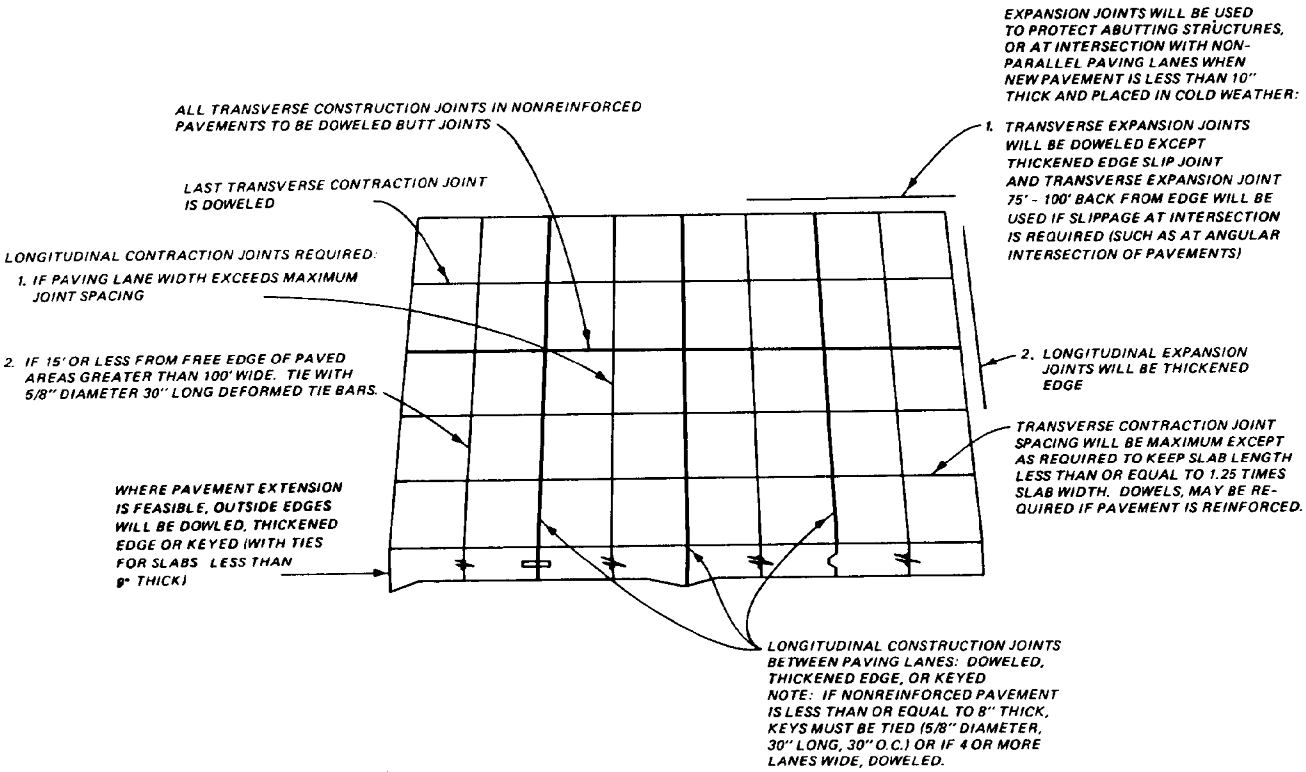


Figure 15-2. Joint Layout for Vehicular Parking Areas.

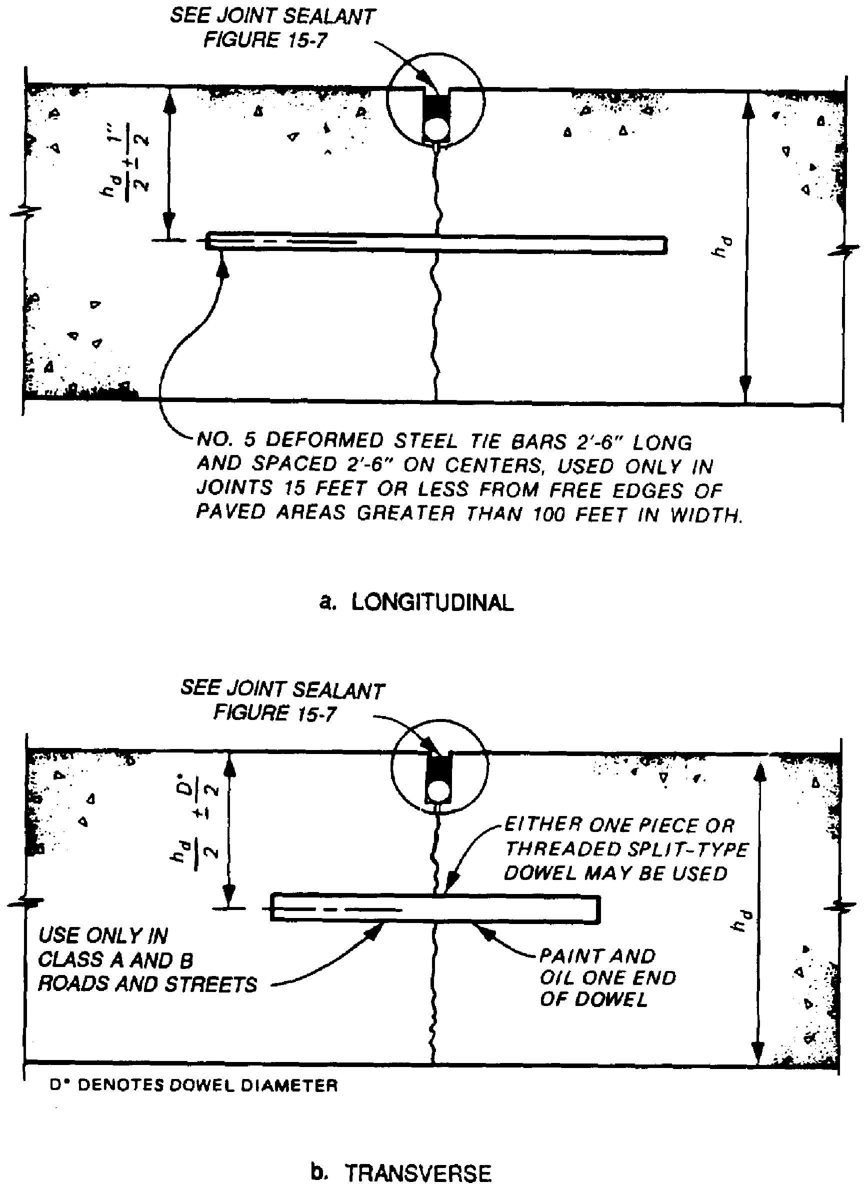
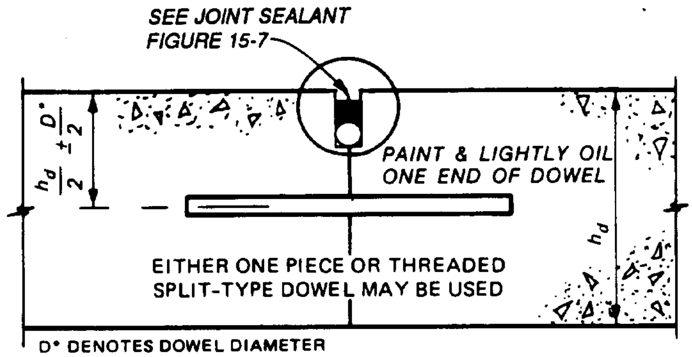
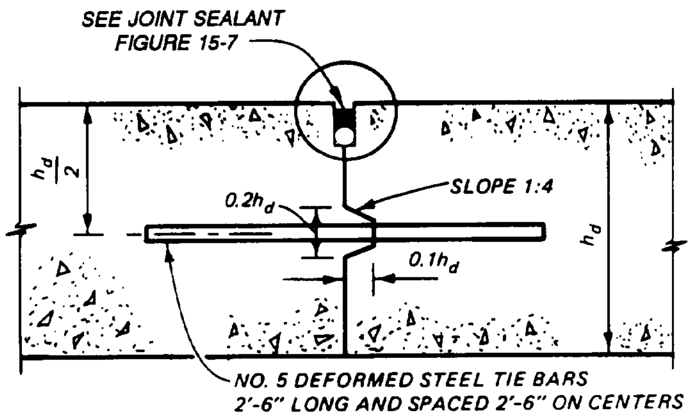


Figure 15-3. Contraction Joints for Plain Concrete Pavements.



a. DOWELED TRANSVERSE OR LONGITUDINAL



NOTES: TO BE USED ONLY WHEN SLAB THICKNESS IS 9 INCHES OR MORE

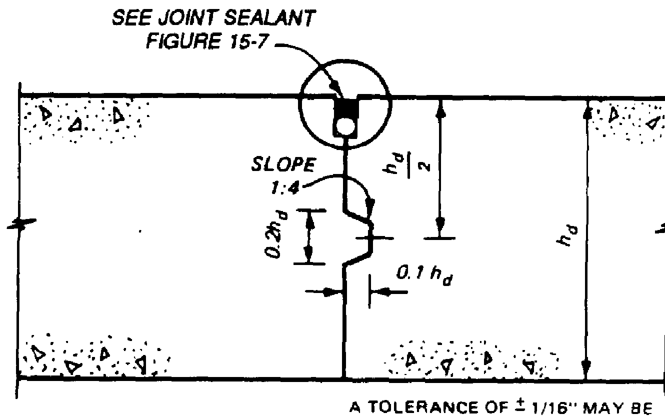
A TOLERANCE OF ± 1/16" MAY BE ALLOWED FOR KEY DIMENSIONS AND LOCATION

VERTICAL TOLERANCE OF ± 1/4" ALLOWED FOR PLACEMENT OF TIE BAR

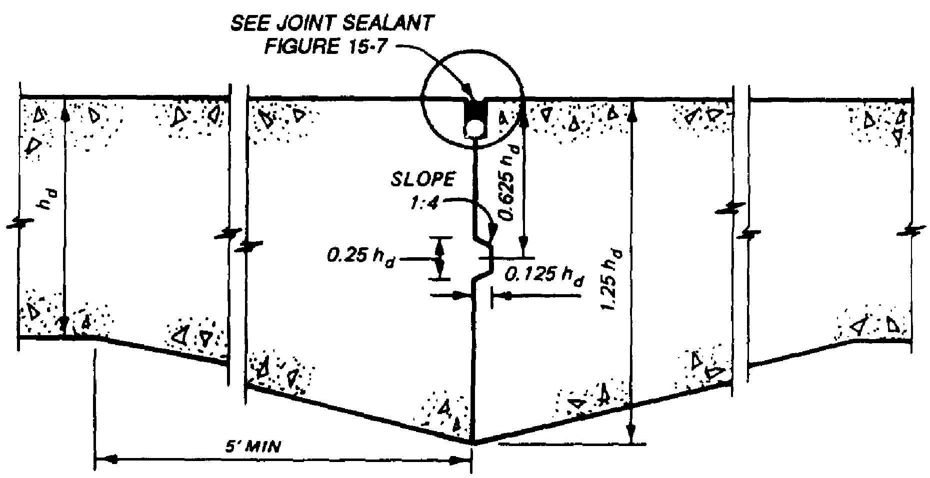
TIED JOINTS IN PAVEMENT WIDTH > 75 FT IS NOT RECOMMENDED.

b. KEYED AND TIED LONGITUDINAL

Figure 15-4. Construction Joints for Plain Concrete Pavements. (Sheet 1 of 4)



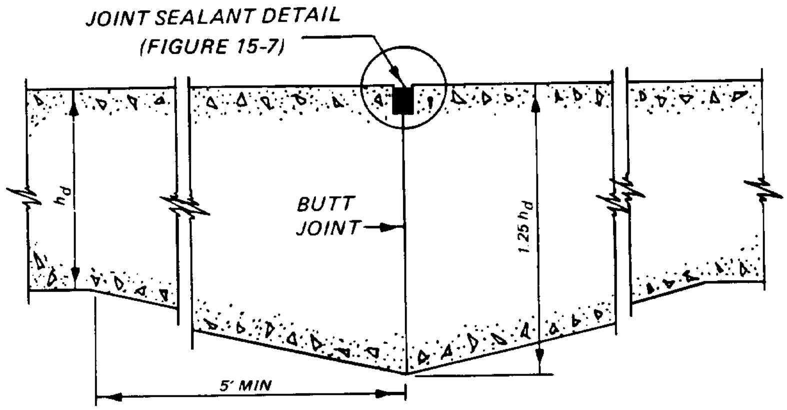
c. KEYED LONGITUDINAL



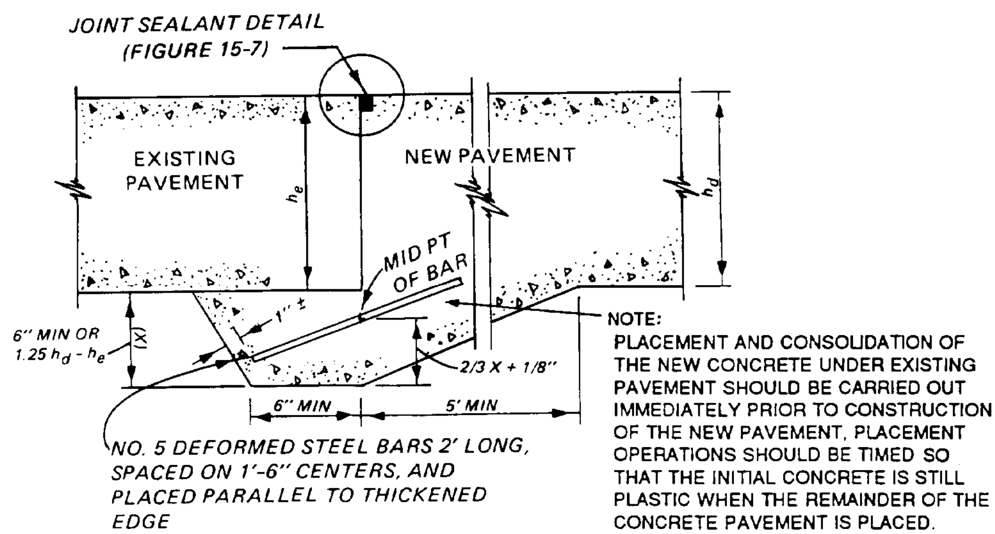
A TOLERANCE OF ± 1/16" MAY BE
ALLOWED FOR KEY DIMENSIONS
AND LOCATION

d. KEYED THICKENED EDGE LONGITUDINAL

Figure 15-4. Construction Joints for Plain Concrete Pavements. (Sheet 2 of 4)

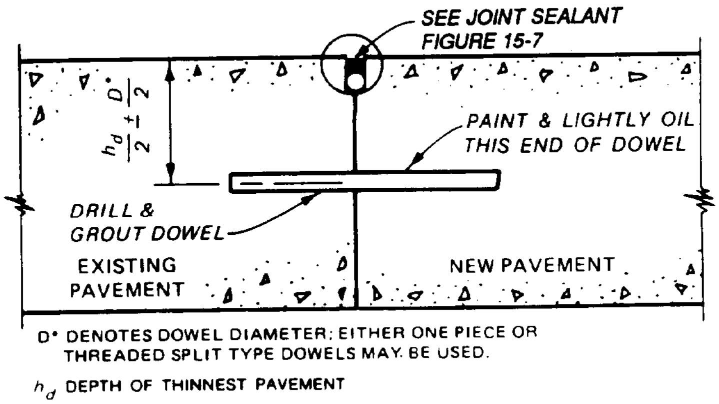


e. THICKENED EDGE LONGITUDINAL

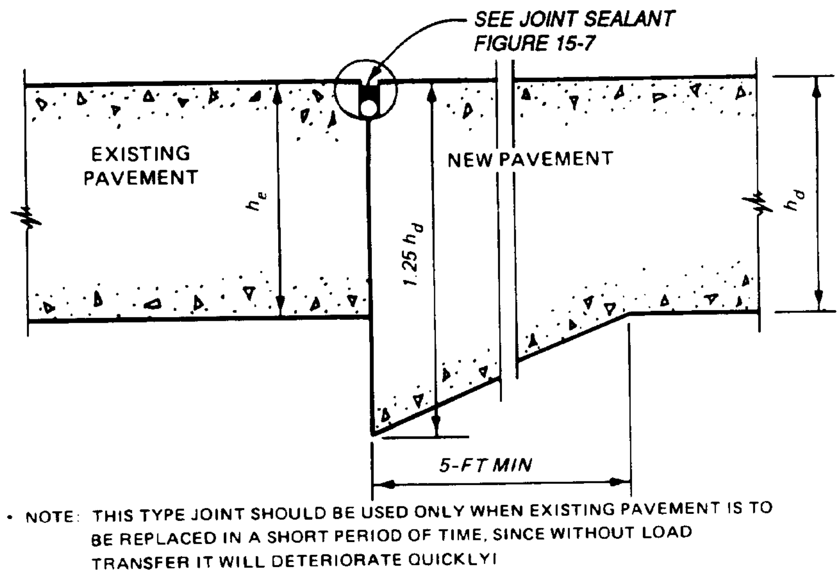


f. SPECIAL JOINT BETWEEN NEW AND EXISTING PAVEMENT TRANSVERSE OR LONGITUDINAL

Figure 15-4. Construction Joints for Plain Concrete Pavements. (Sheet 3 of 4)

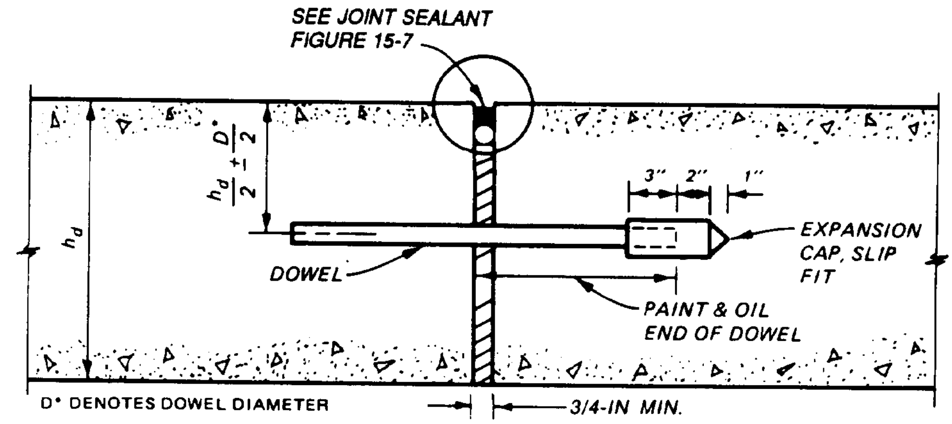


g. DOWELED JOINT BETWEEN
NEW AND EXISTING PAVEMENT

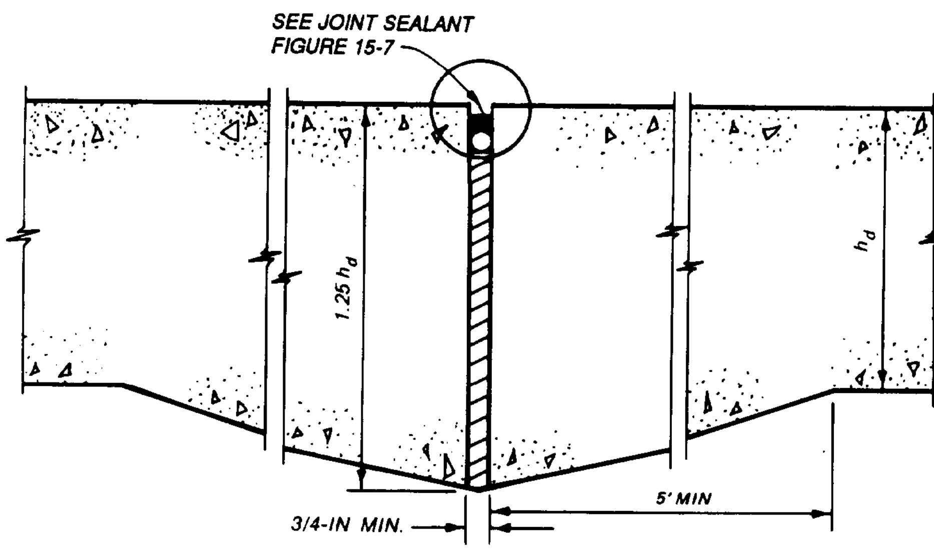


h. THICKENED--EDGED JOINT BETWEEN
NEW AND EXISTING PAVEMENT

Figure 15-4. Construction Joints for Plain Concrete Pavements. (Sheet 4 of 4)



a. TRANSVERSE



b. LONGITUDINAL

Figure 15-5. Expansion Joints for Plain Concrete Pavements.

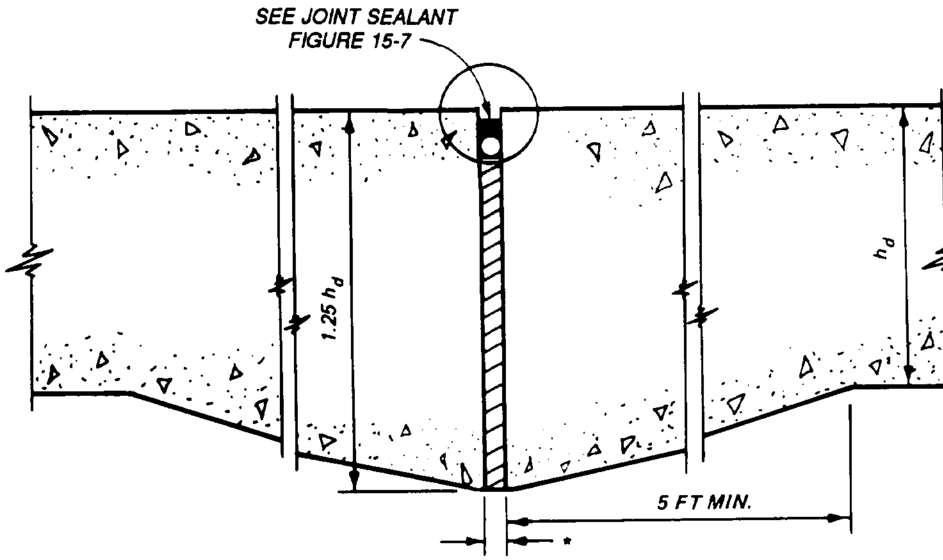
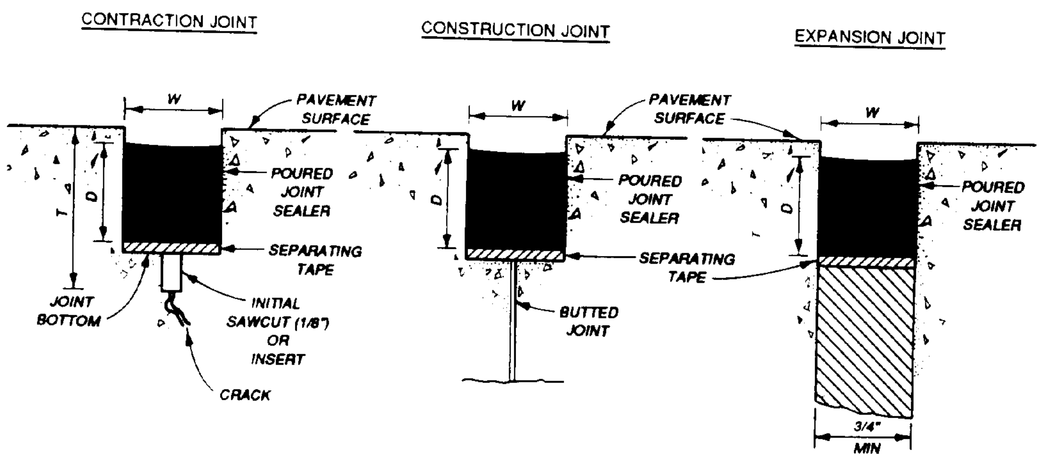


Figure 15-6. Thickened-Edge Slip Joint.

a. Contraction joints. Weakened-plane contraction joints are provided to control cracking in the concrete and to limit curling or warping stresses resulting from drying shrinkage and contraction and from temperature and moisture gradients in the pavement, respectively. Shrinkage and contraction of the concrete cause slight cracking and separation of the pavement at the weakened planes, which will provide some relief from tensile forces resulting from foundation restraint and compressive forces caused by subsequent expansion. Contraction joints will be required transversely and may be required longitudinally depending upon pavement thickness and spacing of construction joints. Instructions regarding the use of sawcuts or preformed inserts to form the weakened plane are contained in TM 5-822-7.

(1) *Width and depth of weakened plane groove.* The width of the weakened plane groove will be a minimum of ⅛ inch and a maximum equal to the width of the sealant reservoir. The depth of the weakened plane groove must be great enough to cause the concrete to crack under the tensile stresses resulting from the shrinkage and contraction of the concrete as it cures. Experience, sum ported by analyses, indicates that this depth should be at least one-fourth of the slab thickness for pavements 12 inches or less, and 3 inches for pavements greater than 12 and less than 18 inches in thickness. In no case will the depth of the groove be less than the maximum nominal size of aggregate used. Concrete placement conditions may influence the fracturing of the concrete and dictate the depth of groove required. For example, concrete placed early in the day, when the air temperature is rising, may experience expansion rather than contraction during the early life of the concrete with subsequent contraction occurring several hours later as the air temperature drops. The concrete may have attained sufficient strength before the contraction occurs so that each successive weakened plane does not result in fracturing of the concrete. As a result, an excessive opening may result where fracturing does occur. To prevent such an opening, the depth of the groove will be increased to one-third of the slab thickness to assure the fracturing and proper functioning of each of the scheduled joints.

(2) *Width and depth of sealant reservoir.* The width and depth of the sealant reservoir for the weakened plane groove will conform to dimensions shown in figure 15-7. The dimensions of the sealant reservoir are critical to satisfactory performance of the joint sealing materials.



W = WIDTH OF SEALANT RESERVOIR (SEE TABLE)
D = DEPTH OF SEALANT (1.0 TO 1.5 X W)
T = DEPTH OF INITIAL SAWCUT OR INSERT TYPE JOINT FORMER (CONTRACTION JOINT)
a. 1/4 SLAB THICKNESS FOR PAVEMENTS LESS THAN 12 INCHES
b. 3 INCHES FOR PAVEMENTS 12-18 INCHES*
c. 1/6 SLAB THICKNESS FOR PAVEMENTS MORE THAN 18 INCHES*

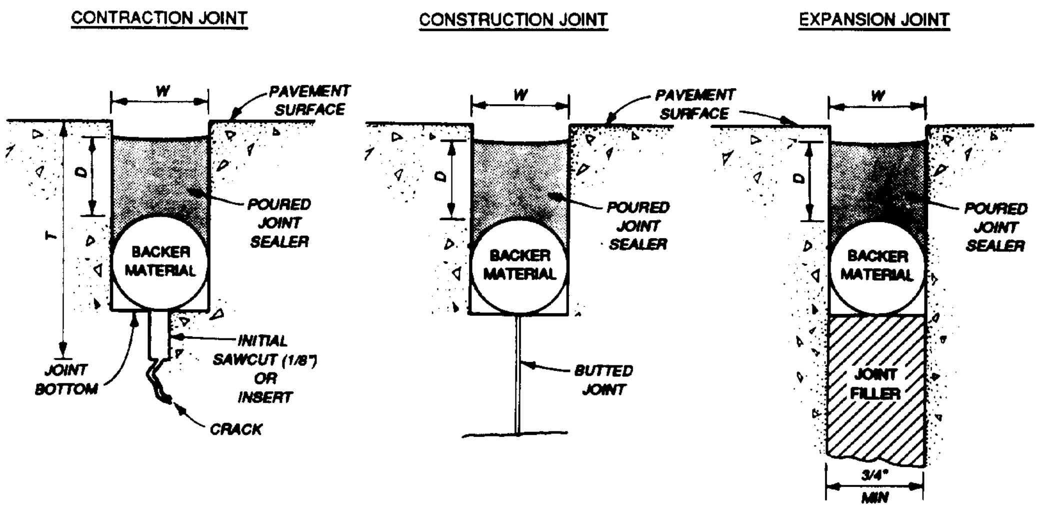
TABLE

JOINT SPACING FT	WIDTH, IN.	
	MIN	MAX
<25	1/2	5/8
25 - 50	3/4	7/8
>50	1.0	1-1/8

*DESIGNER MAY WANT TO CONSIDER REQUIRING 1/4 SLAB THICKNESS

NOTE: TOP OF SEALANT WILL BE 1/8-IN. TO 1/4-IN. BELOW TOP OF PAVEMENT

Figure 15-7. Joint Sealant Details. (Sheet 1 of 3)



W = WIDTH OF SEALANT RESERVOIR (SEE TABLE)
D = DEPTH OF SEALANT (1.0 TO 1.5 X W)
T = DEPTH OF INITIAL SAWCUT OR INSERT TYPE JOINT FORMER (CONTRACTION JOINT)
a. 1/4 SLAB THICKNESS FOR PAVEMENTS LESS THAN 12 INCHES
b. 3 INCHES FOR PAVEMENTS 12-18 INCHES*
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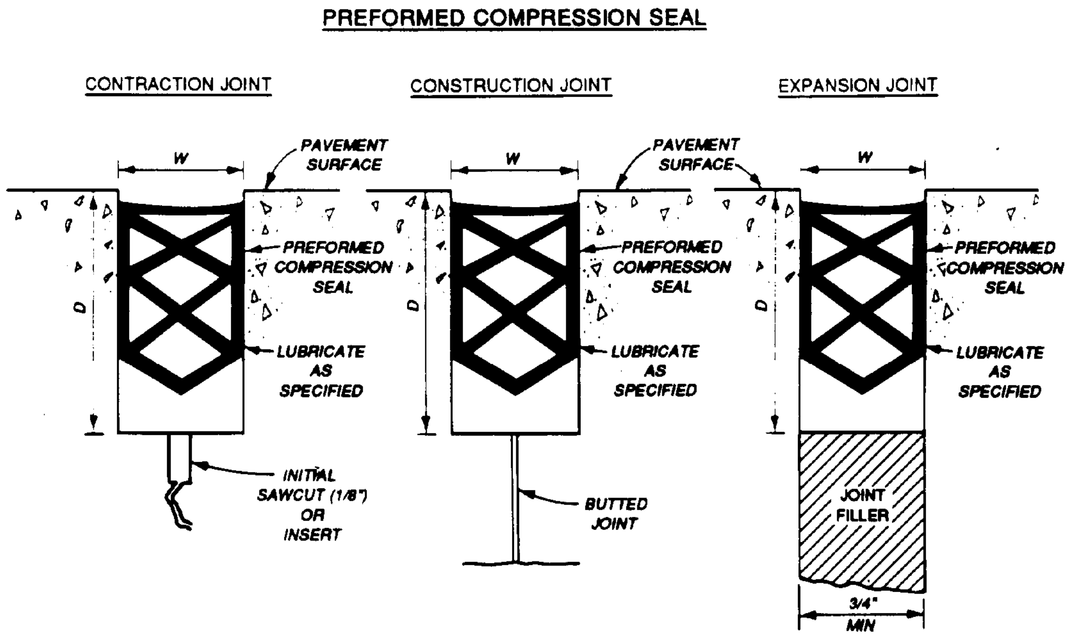
TABLE

JOINT SPACING FT	WIDTH, IN. MIN	WIDTH, IN. MAX
<25	1/2	5/8
25 - 50	3/4	7/8
>50	1.0	1-1/8

*DESIGNER MAY WANT TO CONSIDER REQUIRING 1/4 SLAB THICKNESS

NOTE: TOP OF SEALANT WILL BE 1/8-IN. TO 1/4-IN. BELOW TOP OF PAVEMENT.

Figure 15-7. Joint Sealant Details. (Sheet 2 of 3)



DEPTH & WIDTH: AS RECOMMENDED BY MANUFACTURER PER TYPE OF SEAL BEING USED, (DEPTH NOT LESS THAN 1.5 INCHES)

TOP OF PREFORMED SEAL WILL BE 1/8 - 1/4 INCH BELOW PAVEMENT SURFACE

COMPRESSION SEAL MUST BE IN COMPRESSION AT ALL TIMES.

JOINT SPACING FT	WIDTH-IN.	
	MIN.	MAX.
<25	1/2	5/8
25 - 50	3/4	7/8
>50	1.0	1-1/8

Figure 15-7. Joint Sealant Details (Sheet 3 of 3)

(3) *Spacing of transverse contraction joints.* Transverse contraction joints will be constructed across each paving lane perpendicular to the center line, at intervals of not less than 12 ½ feet, and generally not more than 25 feet (20 feet for Air Force). In regions where the design freezing index is 1,800 or more degree days the maximum spacing should be 20 feet. The joint spacing will be uniform throughout any major paved area, and each joint will be straight and continuous from edge to edge of the paving lane and across all paving lanes for the full width of the paved area. Staggering of joints in adjacent paving lanes can lead to sympathetic cracking and will not be permitted unless reinforcement is used. The maximum spacing of transverse joints that will effectively control cracking will vary appreciably depending on pavement thickness, thermal coefficient and other characteristics of the aggregate and concrete, climatic conditions, and foundation restraint. It is impractical to establish limits on joint spacing that are suitable for all conditions without making them unduly restrictive. The joint spacings in table 15-1 have given satisfactory control of transverse cracking in most instances and should be used as a guide, subject to modification based on available information regarding the performance of existing pavements in the vicinity or unusual properties of the concrete. For best pavement performance, the number of joints should be kept to a minimum by using the greatest joint spacing that will satisfactorily control cracking. However, experience has shown that oblong slabs, especially in thin pavements, tend to crack into smaller slabs of nearly

equal dimensions under traffic. Therefore, it is desirable, insofar as practicable, to keep the length and width dimensions as nearly equal as possible. In no case should the length dimension (in the direction of paving) exceed the width dimension more than 25 percent. Where it is desired to exceed the joint spacing (in table 15-1), a request must be submitted to HQUSACE (CEMP-ET) or the appropriate Air Force Major Command outlining local conditions that indicate that the proposed change in joint spacing is desirable.

Table 15-2. Dowel Size and Spacing for Construction, Contraction, and Expansion Joints.

Pavement thickness inches	Minimum dowel length inches	Maximum dowel spacing inches	Dowel diameter and type
Less than 8.	16	12	¾-inch bar
8 to 11	16	12	1-inch bar
12 to 15	20	15	1- to 1¼-inch bar, or 1-inch extra strength pipe *

* Extra strength pipe will be filled or plugged when used.

(4) *Spacing of longitudinal contraction joints.* Contraction joints will be placed along the center line of paving lanes that have a width greater than the determined maximum spacing of transverse contraction joints in table 15-1. These joints may also be required in the longitudinal direction for overlays, regardless of overlay thickness, to match joints existing in the base pavement unless a bond-breaking medium is used between the overlay and base pavement or the overlay pavement is reinforced.

(5) Doweled and tied contraction joints.

(a) Dowels are required in transverse contraction joints for plain concrete pavements for class A and B roads and streets, reinforced concrete pavements that use slab lengths greater than those in table 15-1, and in the last joint at ends of long paving lanes such as large storage and parking areas. These dowels are required to ensure good joint load transfer under heavy, repeated loads and under conditions where conventional contraction joints may have inadequate load transfer because of excessive joint opening. Table 15-2 presents the size and spacing of dowels.

Table 15-1. Maximum Allowable Spacing of Transverse Contraction Joints

Pavement thickness, inches	Spacing of joint, feet
Less than 9	12½ to 15
9 to 12	15 to 20
Over 12	20 to 25*

*The maximum spacing of transverse contraction joints for Air Force pavements is 20 feet.

(b) For plain concrete pavements, deformed tie bars will be required in longitudinal contraction joints that fall 15 feet or less from the free edge of paved areas that are 100 feet or greater in width. The deformed tie bars will be ⅝ inch in diameter, 30 inches long, and spaced on 30-inch centers. In addition, longitudinal contraction joints placed along the center line of paving lanes that have a width greater than the maximum spacing of transverse contraction joints will be tied using tie bars of the above-mentioned dimensions (fig 15-3).

b. Construction joints. Construction joints may *be* required in both the longitudinal and trans-verse directions. Longitudinal construction joints, generally spaced 20 to 25 feet apart but which may reach 50 feet apart, depending on construction equipment capability, will be provided to separate successively placed paving lanes. Transverse construction joints will be installed at the end of each day's paving operation, and at other points within a paving lane where the placing of concrete is discontinued a sufficient length of time for the concrete to start to set. All transverse construction joints should be located in place of other regularly spaced transverse joints (contraction or expansion types). There are several types of construction joints available for use, as shown in figure 15-4 and as described below. The selection of the type of construction joint will depend on such factors as the concrete placement procedure (formed or slipformed) and foundation conditions.

(1) *Doweled joint.* The doweled joint is the best joint for providing load transfer and maintaining slab alignment. It is a desirable joint for the most adverse conditions such as heavy loading, high traffic intensity, and lower strength foundations. However, because the alignment and placement of the dowel bars are critical to satisfactory performance, this type of joint is difficult to construct, especially for slipformed concrete. However, the doweled joint is required

for all transverse construction joints in plain concrete pavements.

(2) *Thickened-edge joint.* Thickened-edge-type joints may be used instead of other types of joints employing load transfer devices. When the thickened-edge joint is constructed, the thickness of the concrete at the edge is increased to 125 percent of the design thickness. The thickness is then reduced by tapering from the free-edge thickness to the design thickness at a distance of 3 feet from the longitudinal edge. The thickened-edge joint is considered adequate for the load-induced concrete stresses. However, the inclusion of a key in the thickened-edge joint (fig 15-4d) provides some degree of load transfer in the joint and helps to maintain slab alignment; although not required, it is recommended for pavement constructed on low-to medium-strength foundations. The thickened-edge joint may be used at free edges of paved areas to accommodate future expansion of the facility or where wheel loadings may track the edge of the pavement. The use of this type joint is contingent upon adequate base-course drainage meeting requirements of TM 5-820-2/AFM 88-5, Chap 2.

(3) *Keyed joint.* The keyed joint is the most economical method, from a construction standpoint, for providing load transfer in the joint. It has been demonstrated that the key or keyway can be satisfactorily constructed using either formed or slim formed methods. The required dimensions of the joint can best be maintained by forming or slim forming the keyway rather than the key. The dimensions and location of the key are critical to its performance. Deviations exceeding the stated tolerances can result in failure in the joint. Keyed joints should not be used in rigid pavements that are less than 9 inches in thickness. Tie bars in the keyed joint will limit opening of the joint and provide some shear transfer that will improve the performance of the keyed joints. However, tieing all joints in pavement widths of more than 75 feet can result in excessive stresses and cracking in the concrete during contraction.

c. Expansion joints. Expansion joints will be used at all intersections of pavements with structures or with other concrete pavements where paving lanes are perpendicular to each other, and they may be required within the pavement features. A special expansion joint, the slip joint, is required at pavement intersections. The types of expansion joints are the thickened-edge joint, the thickened-edge slip joint, and the doweled type joint (see figs 15-5 and 15-6). Filler material for the thickened-edge and doweled type expansion joint will be a nonextruding type. The type and thickness of filler material and the manner of its installation will depend upon the particular case. Usually, a preformed material of ¾-inch thickness will be adequate; however, in some instances, a greater thickness of filler material may be required. Filler material for slip joints will be either a heavy coating of bituminous material not less than 1/16 inch in thickness when joints match or a normal nonextruding-type material not less than ¼ inch in thickness when joints do not match. Where large expansions may have a detrimental effect on adjoining structures, such as at the juncture of rigid and flexible pavements, expansion joints in successive transverse joints back from the juncture should be considered. The depth, length, and position of each expansion joint will be sufficient to form a complete and uniform separation between the pavements or between the pavement and the structure concerned.

(1) *Between pavement and structures.* Expansion joints will be installed to surround, or to separate from the pavement, any structures that project through, into, or against the pavements, such as at the approaches to buildings or around drainage inlets. The thickened-edge-type expansion joint will normally be best suited for these places (see fig 15-5).

(2) *Within pavements and at pavement intersections.* Expansion joints within pavements are difficult to construct and maintain and often contribute to pavement failures. Their use will be kept to the absolute minimum necessary to pre- vent excessive stresses in the pavement from expansion of the concrete or to avoid distortion of a pavement through the expansion of an adjoining pavement. The determination of the need for and spacing of expansion joints will be based upon pavement thickness, thermal properties of the concrete, prevailing temperatures in the area, temperatures during the construction period, and the experience with concrete pavements in the area. Unless needed to protect abutting structures, expansion joints will be omitted in all pavements 10 inches or more in thickness and also in pavements less than 10 inches in thickness when the concrete is placed during warm weather since the initial volume of the concrete on hardening will be at or near the maximum. However, for concrete placed during cold weather, expansion joints may be used in pavements less than 10 inches thick.

(a) Longitudinal expansion joints within pavements will be of the thickened-edge type (see fig 15-5). Dowels are not recommended in longitu-

dinal expansion joints because differential expansion and contraction parallel with the joints may develop undesirable localized strains and cause failure of the concrete, especially near the corners of slabs at transverse joints. Expansion joints are not required between two adjoining pavements where paving lanes of the two pavements are parallel.

(b) Transverse expansion joints within pavements will be the doweled type (see fig 15-5). There may be instances when it will be desirable to allow some slippage in the transverse joints such as at the angular intersection of pavements to prevent the expansion of one pavement from distorting the other. Then, the design of the transverse expansion joints will be similar to the thickened-edge slip joints (see para 15-6). When a thickened-edge slip joint is used at a free edge not perpendicular to a paving lane, a transverse expansion joint will be provided 75 to 100 feet back from the free edge.

15-3. Dowels.

The important functions of dowels or any other load-transfer device in concrete pavements are to help maintain the alignment of adjoining slabs and to transfer some stresses from loads to the adjacent slab, thereby limiting or reducing stresses in the loaded slab. Different sizes of dowels will be specified for different thicknesses of pavements (see table 15-2). When extra strength pipe is used for dowels, the pipe will be filled with either a stiff mixture of sand-asphalt or portland cement mortar or the ends of the pipe will be plugged. If the ends of the pipe are plugged, the plug must fit inside the pipe and be cut off flush with the end of the pipe so that there will be no protruding material to bond with the concrete and prevent free movement of the dowel. Figures 15-1 and 13-1 show the dowel placement. All dowels will be straight, smooth, and free from burrs at the ends. One end of the dowel will be painted and oiled to prevent bonding with the concrete. Dowels used at expansion joints will be capped at one end, in addition to painting and oiling, to permit further penetration of the dowels into the concrete when the joints close.

15-4. Special Provisions for Slipform Paving.

Provisions must be made for slipform pavers when there is a change in longitudinal joint configuration. The thickness may be varied without stopping the paving train, but the joint configuration cannot be varied without modifying the side forms, which will normally require stopping the paver and installing a header. The following requirements shall apply at a pavement transition area.

a. Header. The header may be set on either side of the transition slab with the transverse construction joint doweled, as required. The dowel size and location in the transverse construction joint should be commensurate with the thickness of the pavement at the header.

b. Transition between different joints. When there is a transition between a doweled longitudinal construction joint and a keyed longitudinal construction joint, the longitudinal construction joint in the transition slab may be either keyed or doweled. The size and location of the dowels or keys in the transition slabs should be the same as those in the pavement with the doweled or keyed joint, respectively.

c. Transition between two keyed joints. When there is a transition between two keyed joints with different dimensions, the size and location of the key in the transition slab should be based on the thickness of the thinner pavement.

15-5. Joint Sealing.

All joints will be sealed to prevent infiltration of surface water and solid substances. Details of the joint sealant are shown in figure 15-7. A jet-fuel resistant (JFR) sealant, either poured or preformed, will be used in the joints of hardstands, washracks, and other paved areas where fuel or other lubricants may be spilled during the operation, parking, maintenance, and servicing of vehicles. Sealants that are not fuel resistant will be used in joints of all other pavements. Poured JFR sealants will conform to Federal Specifications SS-S-200E and SS-S-1614A, and poured non-JFR sealants will conform to Federal Specification 55-S-1401C. Use of SS-S-1401C requires MACOM approval for use on Air Force Projects. Cold poured non-JFR sealants will conform to CRD-C 527. Preformed sealants will conform to ASTM D 2628 and tested according to the procedures in appendix C for jet-fuel resistance. Lubricant for preformed sealants will conform to ASTM D 2835. Preformed sealants must always be compressed 45 to 85 percent of their original width. The selection of pour-able or preformed sealant should be based upon economics. Compression-type preformed sealants are recommended when the joint spacings exceed 25 feet and are required when joint spacings exceed 50 feet.

15-6. Special Joints and Junctures.

Situations will develop where special joints or variations of the more standard type joints will be needed to accommodate the movements that will occur and to provide a satisfactory operational surface. Some of these special joints or junctures are as follows:

a. Slip-type joints. At the juncture of two pavement facilities, expansion and contraction of the concrete may result in movements that occur in different directions. Such movements may create detrimental stresses within the concrete unless provision is made to allow the movements to occur. At such junctures, a thickened-edge slip joint shall be used to permit the horizontal slip- page to occur. The design of the thickened-edge slip joint will be similar to the thickened-edge construction joint (see fig 15-6). The bond-breaking medium will be either a heavy coating of bituminous material not less than $^{1}/_{16}$ inch in thickness when joints match or a normal nonextruding-type expansion joint material not less than ¼ inch in thickness when joints do not match. The $^{1}/_{16}$-inch bituminous coating may be either a low penetration (60 to 70 grade asphalt) or a clay-type asphalt-base emulsion similar to that used for roof coating (see Military Specification MIL-R-3472) and will be applied to the face of the joint by hand brushing or spraying.

b. Joints between new and existing pavements. **A** special thickened-edge joint design (see fig 15-4f) will be used at the juncture of new and existing pavements for the following conditions:

(1) When load-transfer devices (keyways or dowels) or a thickened edge was not provided at the free edge of the existing pavement.

(2) When load-transfer devices or a thickened edge was provided at the free edge of the existing pavement, but neither met the design requirements for the new pavement.

(3) For transverse contraction joints, when removing and replacing slabs in an existing pavement.

(4) For longitudinal construction joints, when removing and replacing slabs in an existing pavement if the existing load-transfer devices are damaged during the pavement removal.

(5) Any other location where it is necessary to provide load transfer for the existing pavements. The special joint design may not be required if a new pavement joins an existing pavement that is grossly inadequate to carry the design load of the new pavement or if the existing pavement is in poor structural condition. If the existing pavement can carry a load that is 75 percent or less of the new pavement design load, special efforts to pro- vide edge support for the existing pavement may he omitted and the alternate thickened-edge joint used (fig 15-4h); however, if omitted, accelerated failures in the existing pavement may be experienced. The new pavement will simply be designed with a thickened edge at the juncture. Any load-transfer devices in the existing pavement should be used at the juncture to provide as much support as possible to the existing pavement. Drilling and grouting dowels in the existing pavement for edge support may he considered as an alternate to the special joint; however, a thickened-edge design will be used for the new pavement at the juncture.